JC07 Rec'd PCT/PTO 04 DEC 2001

FORM PTO-1390 (REV. 10-96) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEY DOCKET NUMBER A-71183/DJB/MAK
		U.S. APPLICATION NO. (If known, sect 37 C.F.R. 1.5) Not Yet Known 10/009325
INTERNATIONAL APPLICATION NO. PCT/AU00/00630	INTERNATIONAL FILING DATE 2 June 2000	PRIORITY DATE CLAIMED 4 June 1999

TITLE OF INVENTION

AIR-SIDE SOLID OXIDE FUEL CELL COMPONENTS

APPLICANT(S) FOR DO/EO/US

Donald JAFFREY

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau. **(see enclosed Form PCT/IB/308)**
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☐ Other items or information.

JC07 Rec'd PCT/PTO 04 DEC 2001

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.53)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
Not Yet Known 10/009325	PCT/AU00/00630	A-71183/DJB/MAK

17. ☒ The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5)):

Search Report has been prepared by the EPO or JPO $890.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) $710.00

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $740.00

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,040.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00

CALCULATIONS (PTO USE ONLY)

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 1,040.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$ 130.00	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	11 -20 =	0	$ 18.00	$ 0.00	
Independent Claims	2 -3 =	0	$ 84.00	$ 0.00	
Multiple dependent claims (if applicable)			$280.00	$ 0.00	
TOTAL OF ABOVE CALCULATIONS =				$ 1,170.00	
Reduction by 1/2 for filing by small entity, if applicable. Applicant claims small entity status. (See 37 CFR 1.27.)	Yes:	No: ✓		$ 0.00	
SUBTOTAL =				$ 1,170.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ 0.00	
TOTAL NATIONAL FEE =				$ 1,170.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				1,170.00	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of $1,170.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 06-1300 (Order No. ____________) in the amount of $ ________ to cover the above fees.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 06-1300 (Order No. A-71183/DJB/MAK).

NOTE: **Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

Michael A. Kaufman, Esq.
FLEHR HOHBACH TEST
ALBRITTON & HERBERT LLP
Four Embarcadero Center - Suite 3400
San Francisco, California 94111-4187
Tel.: (415) 781-1989
Fax: (415) 398-3249

Michael A. Kaufman
SIGNATURE

Michael A. Kaufman
NAME

32,998
REGISTRATION NUMBER

JC07 Rec'd PCT/PTO 04 DEC 2001
10/009325
PATENT

Attorney Docket No.: A-71183/DJB/MAK

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

Donald JAFFREY

NATIONAL PHASE ENTRY OF:
PCT/AU00/00630

Serial No.: Not Yet Assigned

Filing Date: Herewith

For: ***Air-Side Solid Oxide Fuel Cell Components***

Box PCT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

FIRST PRELIMINARY AMENDMENT

Sir:

This Preliminary Amendment accompanies the filing of an application under 35 U.S.C. § 371.

Prior to examination, please amend the above-identified application as follows:

IN THE CLAIMS:

Please amend claims 3, 4, 5, 6, 8, 9 and 10 to read as follows:

3. (amended) A solid oxide fuel cell system component according to claim 1 which contains less than 0.05 wt% Mn.

4. (amended) A solid oxide fuel cell system component according to claim 1 wherein the alloy has a composition, in wt%, of:

Al	6.0 ± 1.0
Si	1.0 ± 0.5
C	0.005 - 0.02
P	≤ 0.04
S	≤ 0.04
Cr	≤ 0.10

(Al + Si) = 6.5 to 7.5

Residue Fe, excluding incidental impurities.

5. (amended) A solid oxide fuel cell system component according to claim 1 wherein the alloy contains no Cr.

6. (amended) A solid oxide fuel cell system component according to claim 1 having a surface layer of Al_2O_3.

8. (amended) A solid oxide fuel cell system component according to claim 1 wherein source material for the alloy at least includes scrap metal.

9. (amended) A solid oxide fuel cell system component according to claim 1 which is a gas separator disposed or adapted to be disposed between adjacent fuel cells in the system.

10. (amended) A solid oxide fuel cell system component according to claim 1 which is a component selected from the group consisting of a manifold, a base plate, a current collector strap, ducting, a heat exchanger and a heat exchanger plate disposed or adapted to be disposed in the solid oxide fuel cell system.

<u>IN THE ABSTRACT OF THE DISCLOSURE</u>

Please add the following new paragraph and heading at page 12, line 1:

Serial No.:: Not Yet Known
Filing Date: Herewith

--ABSTRACT OF THE DISCLOSURE

A solid oxide fuel cell system component that may be exposed to an oxidizing atmosphere within the system is formed from a heat resistant allow that preferably has a wt% composition of Al 5-0, Si 0.1-3.8, Mn $\leq$ 0.5, Cu $\leq$ 0.23, Ni $\leq$ 0.61, C $\leq$ 0.02, P $\leq$ 0.04, S $\leq$ 0.04, Cr < 5, and residue Fe excluding incidental impurities. Preferably the component can function at temperatures exceeding about 750°C.--

REMARKS

The foregoing claim amendments are made to obviate the problem of improper dependency in the multiple dependent claims which existed in the PCT priority document. The foregoing abstract of the disclosure was added because no abstract appeared in the PCT priority document. Appended hereto at page 4 is a marked-up version of the foregoing amendments in which additions to the text are shown with a gray background and deletions with ~~strikeout type~~. Replacement pages numbered 10 through 12 incorporating the changes indicated above are attached hereto and incorporated herein by reference.

The Commissioner is authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 06-1300 (Our Order No. A-71183/DJB/MAK).

Respectfully submitted,
FLEHR, HOHBACH, TEST,
ALBRITTON & HERBERT LLP

Dated: 3 December 2001

By: Michael A. Kaufman
Michael A. KAUFMAN
Reg. No. 32,998

Embarcadero Center - Suite 3400
San Francisco, California 94111-4187
Tel.: (415) 781-1989
Fax: (415) 398-3249

SF-1069476v1

Serial No.:: Not Yet Known
Filing Date: Herewith

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 3, 4, 5, 6, 8, 9 and 10 were amended as follows:

3. (amended) A solid oxide fuel cell system component according to claim 1 ~~or 2~~ which contains less than 0.05 wt% Mn.

4. (amended) A solid oxide fuel cell system component according to ~~any one of claims 1 to 3~~ claim 1 wherein the alloy has a composition, in wt%, of:

Al	6.0 ± 1.0
Si	1.0 ± 0.5
C	0.005 - 0.02
P	≤ 0.04
S	≤ 0.04
Cr	≤ 0.10

(Al + Si) = 6.5 to 7.5

Residue Fe, excluding incidental impurities.

5. (amended) A solid oxide fuel cell system component according to ~~any one of the preceding claims~~ claim 1 wherein the alloy contains no Cr.

6. (amended) A solid oxide fuel cell system component according to ~~any one of the preceding claims~~ claim 1 having a surface layer of Al_2O_3.

8. (amended) A solid oxide fuel cell system component according to ~~any one of the preceding claims~~ claim 1 wherein source material for the alloy at least includes scrap metal.

9. (amended) A solid oxide fuel cell system component according to ~~any one of the preceding claims~~ claim 1 which is a gas separator disposed or adapted to be disposed between adjacent fuel cells in the system.

10. (amended) A solid oxide fuel cell system component according to ~~any one of claims 1 to 8~~ claim 1 which is a component selected from the group consisting of a manifold, a base plate, a current collector strap, ducting, a heat exchanger and a heat exchanger plate disposed or adapted to be disposed in the solid oxide fuel cell system.

<u>IN THE ABSTRACT OF THE DISCLOSURE</u>:

The following text was added:

<u>ABSTRACT OF THE DISCLOSURE</u>

A solid oxide fuel cell system component that may be exposed to an oxidizing atmosphere within the system is formed from a heat resistant allow that preferably has a wt% composition of Al 5-0, Si 0.1-3.8, Mn $\leq$ 0.5, Cu $\leq$ 0.23, Ni $\leq$ 0.61, C $\leq$ 0.02, P $\leq$ 0.04, S $\leq$ 0.04, Cr < 5, and residue Fe excluding incidental impurities. Preferably the component can function at temperatures exceeding about 750°C.

CLAIMS:

1. A solid oxide fuel cell system component which is adapted to be exposed to an oxidising atmosphere in the fuel cell system and which is formed of a heat resistant alloy having a composition, in wt%, of:

Al		5.0 - 10.0
Si		0.1 - 3.8
Mn	≤	0.5
Cu	≤	0.23
Ni	≤	0.61
C	≤	0.02
P	≤	0.04
S	≤	0.04
Cr	<	5.0

Residue Fe, excluding incidental impurities.

2. A solid oxide fuel cell system component according to claim 1 which contains no more than about 8.5 wt% Al.

3. A solid oxide fuel cell system component according to claim 1 which contains less than 0.05 wt% Mn.

4. A solid oxide fuel cell system component according to claim 1 wherein the alloy has a composition, in wt%, of:

Al	6.0 ± 1.0
Si	1.0 ± 0.5
C	0.005 - 0.02
P	≤ 0.04
S	≤ 0.04
Cr	≤ 0.10

(Al + Si) = 6.5 to 7.5

Residue Fe, excluding incidental impurities.

5. A solid oxide fuel cell system component according to claim 1 wherein the alloy contains no Cr.

6. A solid oxide fuel cell system component according to claim 1 having a surface layer of Al_2O_3.

7. A solid oxide fuel cell system component according to claim 6 wherein the Al_2O_3 surface layer has a thickness in the range of from about 1 to about 10 microns, preferably from about 1 to about 3 microns.

8. A solid oxide fuel cell system component according to claim 1 wherein source material for the alloy at least includes scrap metal.

9. A solid oxide fuel cell system component according to claim 1 which is a gas separator disposed or adapted to be disposed between adjacent fuel cells in the system.

10. A solid oxide fuel cell system component according to claim 1 which is a component selected from the group consisting of a manifold, a base plate, a current collector strap, ducting, a heat exchanger and a heat exchanger plate disposed or adapted to be disposed in the solid oxide fuel cell system.

11. A solid oxide fuel cell system in which one or more components adapted to be exposed to a temperature in excess of 750°C and an oxidising atmosphere are in accordance with any one of the preceding claims.

ABSTRACT OF THE DISCLOSURE

A solid oxide fuel cell system component that may be exposed to an oxidizing atmosphere within the system is formed from a heat resistant allow that preferably has a wt% composition of Al 5-0, Si 0.1-3.8, Mn $\leq$ 0.5, Cu $\leq$ 0.23, Ni $\leq$ 0.61, C $\leq$ 0.02, P $\leq$ 0.04, S $\leq$ 0.04, Cr $<$ 5, and residue Fe excluding incidental impurities. Preferably the component can function at temperatures exceeding about 750°C.

10 Rec'd PCT/PTO 04 DEC 2001

10/009325

AIR-SIDE SOLID OXIDE FUEL CELL COMPONENTS

The present invention relates to solid oxide fuel cells and is particularly concerned with components for solid oxide fuel cells systems which are adapted to be exposed to a temperature in excess of 750°C and to an oxidising atmosphere. Such components include gas separators between adjacent fuel cells, and heat exchangers.

The purpose of a gas separator in planar fuel cell assemblies is to keep the oxygen containing gas supplied to the cathode side of one fuel cell separated from the fuel gas supplied to the anode side of an adjacent fuel cell and to conduct heat generated in the fuel cells away from the fuel cells. The gas separator may also conduct electricity generated in the fuel cells away from the fuel cells, but this function may alternatively be performed by a separate member between each fuel cell and the gas separator.

Sophisticated ceramics for use in fuel cell gas separators have been developed which are electrically conductive, but these suffer from a relatively high fragility, low thermal conductivity and high cost. Special metallic alloys have also been developed, but it has proved difficult to avoid the various materials of the fuel cell assembly and the interfaces between them degrading or changing substantially through the life of the fuel cell, particularly insofar as their electrical conductivity is concerned, because of the tendency of different materials to chemically interact at the high temperatures which are required for efficient operation of a solid oxide fuel cell. For example, most metallic gas separators contain substantial quantities of the element chromium which is used to impart oxidation resistance to the metal as well as other properties.

It has been found that where chromium is present in more than minute quantities it may combine with oxygen or oxygen plus moisture to form highly volatile oxide or oxyhydroxide gases under conditions which are typical of those experienced in operating solid oxide fuel cells. These volatile gases are attracted to the cathode-electrolyte interface where they may react to form compounds which are deleterious to the efficiency of the fuel cell. If these chromium reactions are not eliminated or substantially inhibited, the performance of the fuel cell deteriorates with time to the point where the fuel cell is no longer effective.

Several of these metallic alloys and one proposal for alleviating this problem are described in our patent application WO96/28855 in which a chromium-containing gas separator is provided with an oxide surface layer which reacts with the chromium to form a spinel layer between the substrate and the oxide surface layer and thereby tie in the chromium. However, at present these specialist alloys remain expensive for substantial use in fuel cell assemblies, and it would be preferably to have a lower cost alternative.

Special heat resistant steels have also been developed to be stable at high temperature in fuel cell atmospheres. The significant feature of all heat resistant steels is the oxide layer, particularly its type and nature, which is formed when the steel is exposed to mildly and strongly oxidising conditions at elevated temperatures. Heat resisting steels form tight, adherent, dense oxide layers which prevent further oxidation of the underlying metal. These oxide layers are composed of chromium, aluminium or silicon oxides or some combination of them. These oxide layers are very effective in providing a built-in resistance to degradation due to high temperature oxidation.

However, while this feature is used to advantage in many applications, the presence of this oxide layer has until recently been considered to inhibit the use of these steels in key components of solid oxide fuel cells. The oxides, especially those of silicon and aluminium, are electrically insulating at all temperatures, and this is a major problem for those components in a fuel cell which must act as electrical current collectors. Of all the heat resisting steels available, those based on the iron-chromium binary systems are the best in this regard, but they too have severe limitations. In particular, they generally contain more than 12 wt% chromium to provide the desired oxidation resistance, leading to the problems described above. At levels of less than 12 wt% Cr, tight, adherent, dense chromium oxide layers do not form on the iron-chromium alloys and the alloys are unsuitable for use in oxidising atmosphere at elevated temperatures. At chromium contents of 12 wt% or more, special coatings or treatments are again required to prevent the chromium-based gases escaping from a gas separator formed of the alloy.

One approach to alleviating these disadvantages of heat resistant steel gas separators is described in our patent application WO 99/25890. However, this and most other heat resistant steels are specialist materials containing substantial levels of Cr plus other compositional controls which means that their cost will remain high.

Steels having compositions with low levels of Cr have been proposed in US patent specifications 3,657,024 and 3,761,253, but neither specification exemplifies an alloy having an Al content greater than 4.09 wt%. In both specifications the intention was to provide an electrical-sheet steel having magnetic properties, and no emphasis is placed on providing a low-chromium heat resistant steel capable of forming a thin, adherent alumina-based surface scale to provide oxidation resistance to the steel. Furthermore, no suggestion is made in either specification of providing an alloy which is suitable for use in components on the air side of a solid oxide fuel cell system.

It is an object of the present invention to provide a component for a solid oxide fuel cell system formed of a heat resistant steel which is adapted to be exposed to a temperature in excess of 750°C and to an oxidising atmosphere, but in which the aforementioned disadvantages associated with having high levels of Cr may be alleviated.

According to the present invention there is provided a solid oxide fuel cell system component which is adapted to be exposed to an oxidising atmosphere in the fuel cell system and which is formed of a heat resistant alloy having a composition, in wt%, of:

Al		5.0 - 10.0
Si		0.1 - 3.8
Mn	≤	0.5
Cu	≤	0.23
Ni	≤	0.61
C	≤	0.02
P	≤	0.04
S	≤	0.04

Cr < 5.0

Residue Fe, excluding incidental impurities.

Further according to the present invention, there is provided a solid oxide fuel cell system in which one or more components adapted to be exposed to a temperature in excess of 750°C and an oxidising atmosphere are formed of a heat resistant alloy having a composition as defined in the immediately preceding paragraph.

The component may be in the form of a manifold, base plate, current collector strap, ducting or, for example, a heat exchanger or heat exchanger plate used in a solid oxide fuel cell system, but preferably the component is a gas separator disposed or adapted to be disposed between adjacent fuel cells.

An advantage of solid oxide fuel cell system components in accordance with the invention is that they are capable of forming a stable Al_2O_3 layer on the surface when exposed to oxidising atmosphere at elevated temperature. The component preferably does not contain any chromium, but levels up to about 5 wt% have been found to not interfere with the formation of an alumina layer which can then prevent the escape of chromium rich vapour. The formation of the alumina layer may be performed by heating in an oxidising atmosphere at a temperature of at least 950°C, preferably no more than 1200°C and more preferably in the range 1000 - 1100°C. The length of the heat treatment is dependent upon the elevated temperature. For example, at temperatures in the range of 1200°C, a sufficient thickness of alumina may be formed on the component surface in 1 hour or less. At the lowest temperature of 950°C, a sufficient thickness of alumina may take 10 - 20 hours or more to form. The alumina layer preferably has a thickness as small as 1 - 3 μm, but greater thicknesses up to 5 or even 10 microns may be acceptable.

A minimum level of 5 wt% Al is necessary in the component in order to form the alumina layer when subjected to the heat treatment. Preferably, the alloy contains more than 5.2 wt% Al. A maximum of about 10 wt% Al is provided in order to ensure that the alloy of the component remains within the cold workability limit for Fe-Si-Al alloys. The maximum may

be varied by other alloying elements which are acceptable in a fuel cell component exposed to oxidising atmosphere at elevated temperature, but the preferred maximum is about 8.5 wt% since no advantage has been recognised in adding more.

The silicon content of the alloy is also restricted by the cold workability considerations and by other steel-making considerations. With increasing aluminium content, the silicon content may be decreased in order to ensure the alloy remains within the cold workability limit, and preferably the Si content is no more than about 1.5 wt%. At higher levels, and possibly even at levels above about 1 wt% Si, processing difficulties may be encountered when large volumes of the alloy are made because of the formation of fayalite at elevated temperature. The presence of Si in the Fe-Al alloy assists the fluidity of the steel at high levels of aluminium during melting. A minimum 0.1 wt% Si also alleviates the formation of iron oxide nodules should the alumina surface layer be damaged. Preferably, the alloy comprises from 6.5 to 7.5 wt% total of Al and Si in combination.

Preferably any manganese present is at levels of less than 0.05 wt% since alloys containing more Mn than this may be difficult to roll.

Manganese and the other non-Fe-Al-Si elements may be present as tramp elements, and advantageously the alloy composition may be produced from selected scrap metal, including, but not restricted to, cast and other forms of aluminium, aluminium-silicon alloys, all other aluminium alloy scrap, recycled steel and aluminium cans, Fe-Si transformer core scrap and plain steel, particularly low alloy plain carbon steels. In addition, ferro-silicon and ferro-aluminium alloys of the type used for modifying steel compositions during production are suitable source materials for the Fe-Al-Si alloy.

The preferred alloy composition is, in wt%:

Al	6.0 ± 1.0
Si	1.0 ± 0.5
C	0.005 - 0.02

P ≤ 0.04

S ≤ 0.04

Cr ≤ 0.10

(Al + Si) = 6.5 to 7.5

Residue Fe, excluding incidental impurities.

The alloys may be prepared by, for example, argon arc melting or any other standard steel making process, such as open hearth, or BOF.

The most preferred alloy composition having no Cr conveys particular benefits for gas separators of solid oxide fuel cell assemblies and other components in contact with the inlet air stream to the cells since any breakdown, damage or loss of the Al_2O_3 layer, for whatever reason, can not lead to Cr egress as it can with all Cr containing steels/other heat resisting steels and alloys.

A component in the form of a gas separator in accordance with the present invention may have gas channels formed on opposed sides, for example as described in our aforementioned patent application WO 96/28855. However, preferably, the gas flow passages are formed in or provided by a mesh or other structure provided between the respective side of the gas separator and the adjacent electrode, for example as described in our patent application WO 98/57384.

Most preferably, a gas separator in accordance with the invention would be used with a separate electrical conductor between the gas separator and each electrode. One proposal for separate electrical conductors on respective sides of a gas separator is disclosed in our patent application WO 99/13522.

Examples:

The Fe-Al-Si alloy system was investigated to find a suitable alumina-forming alloy for particular application as a non-current collecting gas separator. Initial work was conducted on

a total of 12 alloy compositions, including one quaternary alloy containing chromium. Alloys were prepared by argon arc melting and their oxidation behaviour and mechanical properties were assessed. Compositions are listed in Table I below.

Table 1. Alloy compositions by atomic %

Alloy No	Nominal Composition, at. %	Alloy No	Nominal Composition, at. %
1	Fe-10.5Al-2Si	7	Fe-11.5Al-2Si
2	Fe-4Al-5Si	8	Fe-1Al-7Si
3	Fe-20Al-1 Si-5Cr	9	Fe-12Al-1.25Si
4	Fe-5Al-4.5Si	10	Fe-13 Al-1Si
5	Fe-20Al-1Si	11	Fe-14Al-0.75Si
6	Fe-15Al-0.5Si	12	Fe-11Al-1.85Si

In the Fe-Al-Si ternary system atomic % equates to approximately 2 x weight %.

Most of the alloys in Table 1 (Alloy Nos 1, 2, 4, and 6-12) fall within the α-Fe phase field (corresponding to the cold-working range) of the ternary Fe-Al-Si system. Alloy 5 and alloy 3, based on the ductile Fe-20Al (at.%), fall just outside this range but were still found to be workable.

A second series of alloys 15 to 19 was prepared with selected additions to determine the effect of minor elements, commonly present in stainless steel scrap, on rolling and oxidation behaviour. Compositions are listed in Table 2.

Table 2. Alloy Compositions by atomic %

Alloy Number	Composition, at.%
15	Fe-11.5Al-2Si-1Mn
16	Fe-11.5Al-2Si-0.2Cu
17	Fe-11.5Al-2Si-0.55Ni
18	Fe-11.5Al-2Si-0.2Cu-0.5Ni
19	Fe-11.5Al-2Si-1Mn-0.2Cu-0.5Ni

All alloys 1 - 12 and 15-19 were successfully hot rolled at 900°C. Small ingot samples were rolled to approximately 1mm thickness, using ~30% roll-reductions. All rolled alloys were posted-annealed at 900°C for 1 hour and all were successfully cold rolled, using ~35% roll-reductions, except for Alloy No. 3.

Oxidation Behaviour

Oxidation tests on alloys 1- 12 and 15-19 were conducted at 900°C for 100 hours in static air and the oxidised samples were examined by XRD and SEM. All of the alloys produced thin, adherent alumina surface scales, except for Alloy Nos. 2 - 4 and 8. In the case of alloys 2, 3, 4 and 8, nodular iron oxides or multi-layered scales were formed and some spalling was observed. Continued growth of these iron oxides over longer exposure times resulted in the catastrophic failure of the scales. In the case of alloy 5, there were signs that nodules had begun to form in isolated locations, perhaps indicating the boundary between compositions forming stable oxide layers and those lacking this property. In the case of alloy 8 SiO_2-based scales were produced, with no alumina surface scale, and the alloy would produce processing difficulties in larger volumes due to the formation of fayalite. No silicon oxides were detected in any of the samples, except sample 8, by XRD, but silicon was detected in the alumina scales using EDAX.

This shows that Fe-Al-Si alloys having a composition range in accordance with the invention are capable of forming thin, adherent alumina oxidation resistant surface layers. This

permits the alloys to be used in non-electrically conductive, heat resistant components on the oxygen-containing gas side of a fuel cell assembly, particularly in gas separators. The alloys in accordance with the invention have thermal conductivities suitable to enable them to readily transfer heat away from the adjacent fuel cell or cells.

Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications which fall within its spirit and scope. The invention also includes all of the steps, features, compositions and compounds referred to or indicated in this specification, individually or collectively, and any and all combinations of any two or more of said steps, features, compositions and components.

CLAIMS:

1. A solid oxide fuel cell system component which is adapted to be exposed to an oxidising atmosphere in the fuel cell system and which is formed of a heat resistant alloy having a composition, in wt%, of:

Al		5.0 - 10.0
Si		0.1 - 3.8
Mn	≤	0.5
Cu	≤	0.23
Ni	≤	0.61
C	≤	0.02
P	≤	0.04
S	≤	0.04
Cr	<	5.0

Residue Fe, excluding incidental impurities.

2. A solid oxide fuel cell system component according to claim 1 which contains no more than about 8.5 wt% Al.

3. A solid oxide fuel cell system component according to claim 1 or 2 which contains less than 0.05 wt% Mn.

4. A solid oxide fuel cell system component according to any one of claims 1 to 3 wherein the alloy has a composition, in wt%, of:

Al	6.0 ± 1.0
Si	1.0 ± 0.5
C	0.005 - 0.02
P	≤ 0.04
S	≤ 0.04
Cr	≤ 0.10

(Al + Si) = 6.5 to 7.5

Residue Fe, excluding incidental impurities.

5. A solid oxide fuel cell system component according to any one of the preceding claims wherein the alloy contains no Cr.

6. A solid oxide fuel cell system component according to any one of the preceding claims having a surface layer of Al_2O_3.

7. A solid oxide fuel cell system component according to claim 6 wherein the Al_2O_3 surface layer has a thickness in the range of from about 1 to about 10 microns, preferably from about 1 to about 3 microns.

8. A solid oxide fuel cell system component according to any one of the preceding claims wherein source material for the alloy at least includes scrap metal.

9. A solid oxide fuel cell system component according to any one of the preceding claims which is a gas separator disposed or adapted to be disposed between adjacent fuel cells in the system.

10. A solid oxide fuel cell system component according to any one of claims 1 to 8 which is a component selected from the group consisting of a manifold, a base plate, a current collector strap, ducting, a heat exchanger and a heat exchanger plate disposed or adapted to be disposed in the solid oxide fuel cell system.

11. A solid oxide fuel cell system in which one or more components adapted to be exposed to a temperature in excess of 750°C and an oxidising atmosphere are in accordance with any one of the preceding claims.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 December 2000 (14.12.2000)

PCT

(10) International Publication Number
WO 00/75389 A1

(51) International Patent Classification[7]: C22C 38/06, 38/16, 38/08, 38/18, 38/34, 38/20, 38/40, 38/42, H01M 2/16, 8/12

(21) International Application Number: PCT/AU00/00630

(22) International Filing Date: 2 June 2000 (02.06.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PQ 0789 4 June 1999 (04.06.1999) AU

(71) Applicant (*for all designated States except US*): CERAMIC FUEL CELLS LIMITED [AU/AU]; 170 Browns Road, Noble Park, VIC 3174 (AU).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): JAFFREY, Donald [AU/AU]; 2 Bonnieview Road, Mount Dandenong, VIC 3767 (AU).

(74) Agents: HUNTSMAN, Peter, Harold et al.; Davies Collison Cave, 1 Little Collins Street, Melbourne, VIC 3000 (AU).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 00/75389 A1

(54) Title: AIR-SIDE SOLID OXIDE FUEL CELL COMPONENTS

(57) Abstract: A solid oxide fuel cell component, such as a gas separator, which is adapted to be exposed to an oxidising atmosphere in the fuel cell system, and which is formed of a heat resistant alloy having a composition, in wt.%, of 5.0-10.0 Al, 0.1-3.8 Si, ≤ 0.5 Mn, ≤ 0.23 Cu, ≤ 0.61 Ni, ≤ 0.02C, ≤ 0.04 P, ≤ 0.045, < 5.0 Cr, and residue Fe. Preferably Cr ≤ 0.10 wt.%. In use the component has a thin, dense, adherent surface layer of Al_2O_3.

#4

10 Rec'd PCT/PTO 13 MAY 2002

DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled AIR-SIDE SOLID OXIDE FUEL CELL COMPONENTS, the specification of which

☐ is attached hereto.

(check one)

☐ was filed on ______________ as Application Serial No. ______________ and was amended on ______________. (if applicable)

[X] International Patent Application No PCT/AU00/00630 filed 2 June, 2000

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Patent Office all information known to me to be material to patentability as defined in 37 C.F.R. 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed Yes	Priority Claimed No
PQ0789/99	Australia	4 June, 1999	☒	☐
PCT/AU00/00630		2 June, 2000	☒	☐
			☐	☐

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose to the Patent Office all information known to me to be material to patentability as defined in 37 C.F.R. 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby appoint the following attorneys or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Harold C. Hohbach, Reg. No. 17,757; Aldo J. Test, Reg. No. 18,048; Donald N. MacIntosh, Reg. No. 20,316; Edward S. Wright, Reg. No. 24,903; David J. Brezner, Reg. No. 24,774; Robert B. Chickering, Reg. No. 24,286; Richard F. Trecartin, Reg. No. 31,801; Steven F. Caserza, Reg. No. 29,780; Edward N. Bachand, Reg. No. 37,085; R. Michael Ananian, Reg. No. 35,050; Robin M. Silva, Reg. No. 38,304; Michael A. Kaufman, Reg. No. 32,988; Maria S. Swiatek, Reg. No. 37,244; Todd A. Lorenz, Reg. No. 39,754; Karen S. Smith, Reg. No. 31,426; Robert H. Pinsker, Reg. No. 42078; Steven M. Freeland, Reg. No. 42,553; Larry Mendenhall, Reg. No. 38,555; Diane J. Mason, Reg. No. 43,777; William E. Nuttle, Reg. No. 42,943; James J. Diehl, Reg. No. 47,527; Renée M. Kosslak, Reg. No. 47,717; Brian T. Clarke, Reg. No. 45,552; Anne M. Shyjan, Reg. No. 47,086; David C. Foster, Reg. No. 44,685; and Victor E. Johnson, Reg. No. 41,546; provided that if any one of said attorneys ceases being affiliated with the law firm of FLEHR HOHBACH TEST ALBRITTON & HERBERT LLP as partner, employee or of counsel, such attorney's appointment as attorney and all powers derived therefrom shall terminate on the date such attorney ceases being so affiliated.

24

Direct all telephone calls to * at (415) 781-1989.

Address all correspondence to:

Flehr Hohbach Test Albritton & Herbert LLP
Four Embarcadero Center - Suite 3400
San Francisco, California 94111-4187

File No.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, §1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00

Full name of sole or first inventor:	* Donald JAFFREY
Inventor's signature:	x D. Jaffrey
Date:	x 23rd January 2002
Residence:	* Mount Dandenong, Victoria, Australia AU
Citizenship:	*Australian
Post Office Address:	*2 Bonnieview Road, Mount Dandenong, Victoria 3767, Australia

Full name of second joint inventor, if any:	*
Inventor's signature:	
Date:	
Residence:	*
Citizenship:	*
Post Office Address:	*

DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION